A report to accompany the

Geologic Map of the Wagner Wash Well 7.5' Quadrangle, Maricopa County, Arizona

by

Charles A. Ferguson, Jon E. Spencer, Philip A. Pearthree, Ann Youberg, and John J. Field

Arizona Geological Survey Digital Geologic Map DGM-38

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Introduction

The Wagner Wash Well 7.5' Quadrangle includes the western fringe of the central White Tank Mountains, the western piedmont of the White Tank Mountains, the south-flowing Hassayampa River, and a small part of the piedmont west of the Hassayampa River. Mapping was done as part of a multiyear mapping program directed at producing complete geologic-map coverage for the Phoenix metropolitan area and was done under the joint State-Federal STATEMAP program, as specified in the National Geologic Mapping Act of 1992. This map is one of six 1:24,000-scale geologic maps, produced with STATEMAP funding this year, that together cover most of the Hassayampa Plain area. Mapping was jointly funded by the Arizona Geological Survey and the U.S. Geological Survey under STATEMAP Program Contract #03HQAG0114.

Surficial Geology

Surficial geology was mapped primarily using aerial photos taken in 1979 for the Bureau of Land Management. The original surficial geologic mapping of this quadrangle was done in 1990 and 1991 (Field and Pearthree, 1991b). This mapping was reviewed and revised in the summer of 2004. Unit boundaries were spot-checked in the field, and mapping was supplemented by field observations during spring, 2004. The physical characteristics of Quaternary alluvial surfaces (channels, alluvial fans, floodplains, stream terraces) evident on aerial photographs and in the field were used to differentiate their associated deposits by age. This mapping was transferred to a digital orthophotoquad base from 2002 provided by the Flood Control District of Maricopa County. Mapping was compiled in a GIS format and the final linework was generated from the digital data. Surficial deposits of the map area were then correlated with regional deposits to roughly estimate their ages. The mapping of Field and Pearthree (1991b) was incorporated into this map with contacts modified extensively in some parts of the map based on reinterpretation of geologic relationships and the higher-quality digital aerial photo base that is currently available.

Several characteristics evident on aerial photographs and on the ground were used to differentiate and map various alluvial surfaces. The color of alluvial surfaces depicted on aerial photographs is primarily controlled by soil color, and to a lesser extent, rock varnish. Significant soil development begins on an alluvial surface after it becomes isolated from active flooding and depositional processes (Gile et al., 1981; Birkeland, 1999). Over thousands of years, distinct soil horizons develop. Two typical soil horizons in Pleistocene alluvial sediments of Arizona are reddish brown argillic horizons and white calcic horizons. As a result, on color aerial photographs older alluvial surfaces characteristically appear redder or whiter (on more eroded surfaces) than younger surfaces. Older surfaces have a dark brown color where darkly varnished desert pavements are well preserved. Differences in the drainage patterns between surfaces provide clues to surface age and potential flood hazards. Young alluvial surfaces that are subject to flooding commonly display distributary (branching downstream) or braided channel patterns; young surfaces may have very little developed drainage if unconfined shallow flooding predominates. Dendritic tributary drainage patterns are characteristic of older surfaces that are not subject to extensive flooding. Topographic relief between adjacent alluvial surfaces and the depth of entrenchment of channels can be determined using stereo-paired aerial photographs and topographic maps. Young flood-prone surfaces appear nearly flat on aerial photographs and are less than 1 m above channel bottoms. Active channels are typically entrenched 1 to 10 m below older surfaces. Comparisons of calcic horizon development on the White Tank Mountains piedmont with other soil sequences in the western United States provide one of the few methods of estimating the ages of the different alluvial surfaces (Gile et al, 1981; Machette, 1985). Calcic horizon development varies from fine white filaments of calcium carbonate in young soils to soil horizons completely plugged with calcium carbonate (caliche) in very old soils.

The gradual build up and decay of cosmogenic radionuclides can be used to estimate the ages of surficial deposits. Radionuclides such as ^{26}Al and ^{10}Be accumulate in minerals as a result of bombardment by cosmic rays. Accumulation rates decrease fairly dramatically with depth, so minerals need to be within a few meters of the surface to accumulate radionuclides are a detectable rate (Cerling and Craig, 1994). In addition, if clasts are exposed at or near the surface and later buried, radionuclides can be used to estimate the age of burial and erosion rates since they were buried. Robinson (2002) collected and analyzed samples from Ty, Qo, and Qio deposits on the upper piedmont of the Wagner Wash Well quadrangle (approximate UTM coordinates 347000 E, 3714500 N). Based on her analysis, she estimated ages of 2-2.75 Ma for the uppermost Ty deposits, 1.2 Ma for Qo deposits, and 700 ka for Qio deposits (Robinson, 2002). These estimates are very consistent with previous age estimates for these units based on correlation with other chronosequences of surficial deposits in the Southwest (i.e., Bull, 1991).

Variations in the distribution of surfaces of different ages and sources and concomitant variations in dissection across the quadrangle provide evidence regarding the recent geologic evolution of this area and the distribution of flood hazards. Generally, areas near the Hassayampa River are moderately to deeply dissected, and upper piedmont areas are moderately dissected. Dissection in middle piedmont areas varies substantially across the quadrangle. Very old terraces (unit Qor and Qi_1r) that are perched high above the modern Hassayampa River record past locations of the river bed. Qor terraces cap a substantial aggradational sequence that was deposited during late Tertiary to early Quaternary. At that time the river was not entrenched and probably was depositing sediment across a fairly broad floodplain in the western part of the quadrangle. Since then the Hassayampa River has downcut 20 to 30 m, with dissection increasing to the north. The effects of this downcutting are expressed by incision of tributary drainages through much of the White Tanks piedmont. This is especially evident in the northern part of this quadrangle, where modern piedmont drainages link directly to the Hassayampa River or Wagner Wash, a deeply incised large tributary. In this part of the quadrangle, Pleistocene deposits are thoroughly dissected and the extent of Holocene deposits is quite limited. In the southern part of the quadrangle, piedmont drainages turn to the southwest and south before eventually joining the Hassayampa or Gila rivers. Incision along these drainages is quite variable, but most have major expansion reaches with distributary channel networks and extensive, thin young deposits in the middle piedmont. These areas are of particular concern because of the potential for widespread inundation and changes in channel positions during floods (Field and Pearthree, 1991a).

Bedrock Geology

Bedrock was mapped between November, 2003 and April, 2004 by Ferguson and Spencer. For this study, approximately 800 field stations were located using hand-held GPS (accurate to within 10-30 m). Field observations at each station were recorded in a database that will eventually be available through the Arizona Geological Survey's Digital Information (DI) publication series. Observations include outcrop descriptions, orientation of contacts, information regarding samples that were collected, and structural measurements. Many more structural measurements were taken than could be represented on the map.

Structure. Tectonic foliation in the western White Tank Mountains is consistently NE-striking, moderately to steeply dipping, and present only in Early Proterozoic rocks. The fabrics are therefore unlikely to be related to Mid-Tertiary extension (Rehrig and Reynolds, 1980; Reynolds and DeWitt, 1991; Reynolds et al., 2002). In the eastern part of the range, moderately to gently dipping mylonitic foliation with NE-trending stretching lineation affects all rocks, including Middle Tertiary granitic units (Brittingham, 1985). These gently dipping fabrics are thought to be related to a top-to-the-NE detachment fault that arches over the crest of the range (Kruger et al., 1998). The fault, named the White Tank detachment, is exposed only in the western foothills of the range in the east-central part of the map area.

The White Tank detachment fault juxtaposes chloritic altered granitic rocks in the footwall (east) with strongly oxidized, intensely fractured, and calcite veined volcanic rocks in the hanging wall (west). The fault displays classic features of core-complex detachment fault systems, with a well-developed chloritic microbreccia, and pervasive chloritic alteration in the footwall. The fault is cut by a series of minor, NW-striking, high-angle normal faults that complicate its map pattern. Where it is exposed, the detachment fault has a consistent SSE strike and gentle 13-15° WSW dip. To the south, the fault curves sharply to the SW and projects beneath Quaternary deposits.

Just to the north of its northernmost exposure, we interpret the White Tank detachment fault to curve sharply to the west in much the same way that it does at its southernmost exposure. Farther north, in the northerly adjacent Daggs Tank 7.5' Quadrangle map area (Pearthree et al., 2004), we show the fault curving gently around the northern end of the range as defined by a series of small hills composed of Mid-Tertiary rhyolite lava and tuff (Tr, Trq, Tt) that constitute the only exposures of hanging-wall rock in the northern part of the range. The northwesternmost exposures of the footwall consist of intensely fractured and pervasively hematite-stained plutonic rocks. Previous interpretations of the northern continuation of the White Tank detachment fault (Barrett, 1976; Reynolds and Grubensky, 1993; Kruger et al., 1998) show the fault striking nearly due north through a complex suite of plutonic rocks in the NE corner of this map area. A prominent fault is present in this area, herein named the Wagner fault, but two key lines of evidence argue strongly that it is not a continuation of the White Tank detachment: (1) contrasting styles of alteration associated with the two faults, and 2) lack of significant offset of units across the Wagner fault (in contrast to the detachment fault).

The Wagner fault dips 40-60° to the west, and is well exposed in several areas in the northeast corner of the map area. The fault has a prominent breccia zone with multiple splays up to 20 m wide, but there is no profound difference in style of alteration across the fault. In the northeastern corner of the map area (sec. 11) the Wagner fault is marked by a 1-5 m thick, chloritic, silicified fault breccia that contains locally abundant, irregular, white calcite veinlets. Hematite-coated fracture surfaces cut the chloritic breccia. Unlike typical detachment faults in the Mojave-Sonoran desert region, the footwall to the Wagner fault does not include silicified microbreccia or a microbreccia ledge (e.g., Rehrig and Reynolds, 1980). The breccia grades downward into highly fractured, somewhat hematitic rock that makes up a prominent, approximately 60 m-high butte just to the east of the fault exposure.

Kinematic indicators along the Wagner fault and its splays indicate both normal and reverse sense of shear. Rocks on either side of the Wagner fault are significantly different on a local scale (less than 1-2 km), which makes it easy to map the fault in areas of poor exposure, but on a more regional (2-5 km) scale, the rock units are quite similar, which suggests that the fault can not have accommodated the several tens of kilometers of offset that has been attributed to the White Tank detachment fault based on regional considerations (Kruger et al., 1998). All of the main units in the hanging wall of the Wagner fault are present in the footwall except the andesite porphyry (TKap). Even though outcrops of the two Middle Proterozoic map units (YXg, YXp) are depicted only in the hanging wall of the Wagner fault, pegmatite dikes and small pods of coarse-grained granite in the footwall probably correlate with these units. Plutonic rocks display the same complex sequence of intrusive relationships on either side of the Wagner fault.

The hanging wall of the White Tank detachment fault is defined largely by the extensive outcrop of supracrustal rocks in the east-central part of this map area. Previous interpretations (Barrett, 1976; Reynolds and Grubensky, 1993; Kruger et al., 1998) show the hanging wall to the detachment including the supracrustal rocks and a large area of plutonic rocks extending into the northeast corner of the map area. If this interpretation is correct, then a nonconformity must exist between the plutonic and supracrustal rocks. Two lines of evidence argue against the presence of such a nonconformity. First, clasts in the conglomeratic rocks of the supracrustal succession (Tc) are atypical of what would be expected if the concealed contact with the plutonic suite to the north is a nonconformity. The clasts are dominated by coarse-grained granite and biotite schist. The nearest exposure of coarse-grained granite is 5 km to the north, and there are no exposures of biotite schist in the northwestern White Tank Mountains. Secondly, the steeply dipping, mostly north-striking strata of the supracrustal rocks strike directly into rocks of the plutonic suite. If a nonconformity is present, it must be faulted and significant rotation must have occurred between the supracrustal and plutonic rocks, and there is no evidence to support this.

The steeply west-dipping volcanic and sedimentary strata in the hanging wall of the White Tank detachment fault have been interpreted to be west-facing (Kruger et al., 1998). No stratigraphic facing indicators were found during our detailed study of the sequence. The poor exposure, somewhat generic appearance (i.e., no distinctive features), and general highly brecciated nature of the units makes it difficult to define any consistent stratigraphic succession that might be used for correlation or for identifying a facing direction. It seems probable that the west-dipping units also young towards the west, but we could not identify any top-to-the east normal faults that would be synthetic with respect to the top-to-the-east White Tank detachment fault. In fact, the only fault we identified that clearly soles into the White Tank detachment dips to the SW, which would make it antithetic to a top-to-the-east detachment.

The steeply tilted volcanic and sedimentary sequence in the hanging wall of the White Tank detachment fault is unconformably overlain by a gently SW-tilted sequence of pebbly sandstone (Ty). These strata are cut by at least one high-angle normal fault that cuts the White Tank detachment. No overlapping relationship between the Ty unit and the White Tank detachment is exposed.

The bedrock hill on the west side of the Hassayampa River consists primarily of Belmont Granite (Tg) which intrudes Early Proterozoic granodiorite (Xgd) in a series of SE-striking, moderately SW-dipping dikes. This is very similar to the preferred orientation of Belmont Granite dikes and possibly related felsite dikes that intrude a similar suite of Early Proterozoic rocks in the southeast corner of the Belmont Mountains ~10 km to the west (Capps et al., 1985; Stimac et al., 1994). This suggests, contrary to previous interpretations (Kruger et al., 1998), that this hill and the eastern Belmont Mountains are not separated by a major fault or tilt-domain boundary.

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